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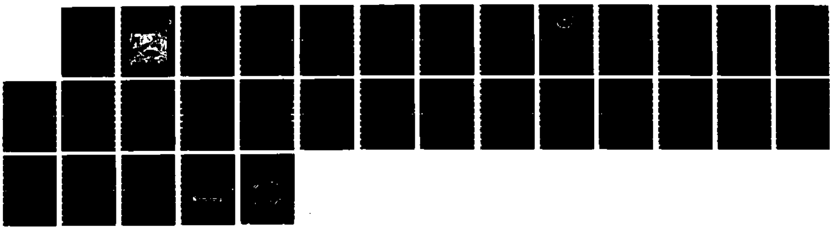

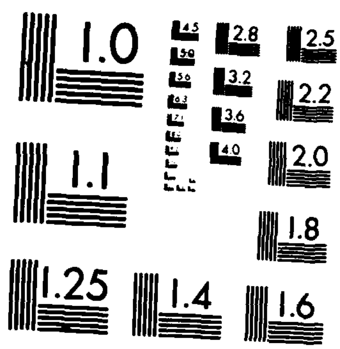

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Biological Report 82 (11.55) TR EL-82-4
June 1986

Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Gulf of Mexico)

BLUE CRAB

Fish and Wildlife Service
U.S. Department of the Interior

Coastal Ecology Group
Waterways Experiment Station
U.S. Army Corps of Engineers

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Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Gulf of Mexico)

BLUE CRAB

by

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Washington, DC 20240

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This series should be referenced as follows:

U.S. Fish and Wildlife Service. 1983-19__. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates. U.S. Fish Wildl. Serv. Biol. Rep. 82(11). U.S. Army Corps of Engineers, TR EL-82-4.

This profile should be cited as follows:

Perry, H.M., and T.D. McIlwain. 1986. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (Gulf of Mexico)--blue crab. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.55). U.S. Army Corps of Engineers, TR EL-82-4. 21pp.

PREFACE

This species profile is one of a series on coastal aquatic organisms, principally fish, of sport, commercial, or ecological importance. The profiles are designed to provide coastal managers, engineers, and biologists with a brief comprehensive sketch of the biological characteristics and environmental requirements of the species and to describe how populations of the species may be expected to react to environmental changes caused by coastal development. Each profile has sections on taxonomy, life history, ecological role, environmental requirements, and economic importance, if applicable. A three-ring binder is used for this series so that new profiles can be added as they are prepared. This project is jointly planned and financed by the U.S. Army Corps of Engineers and the U.S. Fish and Wildlife Service.

Suggestions or questions regarding this report should be directed to one of the following addresses.

Information Transfer Specialist
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or

U.S. Army Engineer Waterways Experiment Station
Attention: WESER-C
Post Office Box 631
Vicksburg, MS 39180

CONVERSION TABLE

Metric to U.S. Customary

Multiply	By	To Obtain
millimeters (mm)	0.03937	inches
centimeters (cm)	0.3937	inches
meters (m)	3.281	feet
kilometers (km)	0.6214	miles
square meters (m^2)	10.76	square feet
square kilometers (km^2)	0.3861	square miles
hectares (ha)	2.471	acres
liters (l)	0.2642	gallons
cubic meters (m^3)	35.31	cubic feet
cubic meters	0.0008110	acre-feet
milligrams (mg)	0.00003527	ounces
grams (g)	0.03527	ounces
kilograms (kg)	2.205	pounds
metric tons (t)	2205.0	pounds
metric tons	1.102	short tons
kilocalories (kcal)	3.968	British thermal units
Celsius degrees	1.8(°C) + 32	Fahrenheit degrees

U.S. Customary to Metric

Multiply	By	To Obtain
inches	25.40	millimeters
inches	2.54	centimeters
feet (ft)	0.3048	meters
fathoms	1.829	meters
miles (mi)	1.609	kilometers
nautical miles (nmi)	1.852	kilometers
square feet (ft^2)	0.0929	square meters
acres	0.4047	hectares
square miles (mi^2)	2.590	square kilometers
gallons (gal)	3.785	liters
cubic feet (ft^3)	0.02831	cubic meters
acre-feet	1233.0	cubic meters
ounces (oz)	28.35	grams
pounds (lb)	0.4536	kilograms
short tons (ton)	0.9072	metric tons
British thermal units (Btu)	0.2520	kilocalories
Fahrenheit degrees	0.5556(°F - 32)	Celsius degrees

CONTENTS

ACKNOWLEDGMENTS

The authors are grateful to Gerald Adkins, Louisiana Department of Wildlife and Fisheries and to Paul Hammerschmidt, Texas Parks and Wildlife Department, for their reviews of the manuscript. A special thanks to Cindy Dickens for typing the manuscript and to Linda Laird for preparing the illustrations.

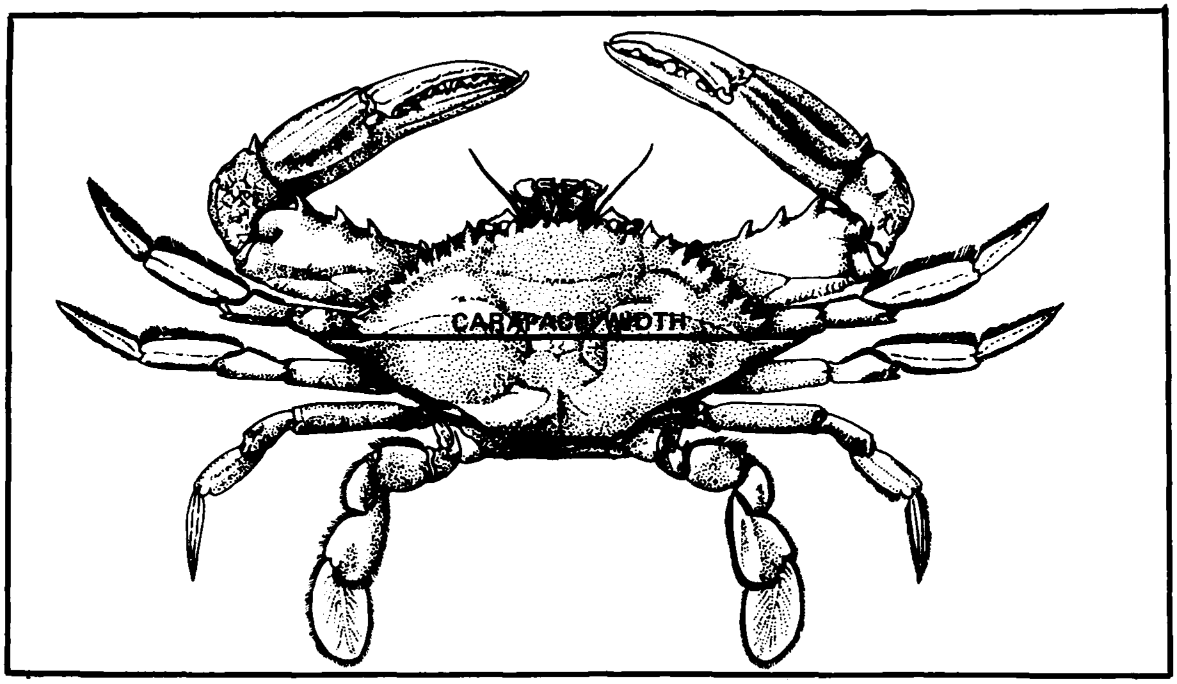

Figure 1. Blue crab (from Rathbun 1930).

NOMENCLATURE/TAXONOMY/RANGE

Scientific name . . . . . Callinectes sapidus Rathbun 1896
Preferred common name . . . Blue crab (Figure 1)
Other common names . . Common edible crab, edible blue crab
Class . . . . Crustacea
Order . . . . Decapoda
Infraorder . . . . Brachyura
Family . . . . Portunidae

Geographical range: Distributed throughout the coastal waters of the Gulf of Mexico (Figure 2). Williams (1974) defined the range as: Occasionally Nova Scotia, Maine, and northern Massachusetts to northern Argentina, including Bermuda and the Antilles; Oresund, Denmark; the Netherlands and adjacent North Sea; southwest France (found twice); Golfo di Genova; northern Adriatic; Aegean, western Black, and eastern Mediterranean seas.

MORPHOLOGY/IDENTIFICATION AIDS

Williams (1974) provided a detailed morphological description. Frontal margin of the carapace with four inner orbital teeth. Antero-lateral margin of carapace with 9 spines or teeth, the posterior-most strongly developed. Carapace about 2.5 times as wide as long, moderately convex and nearly smooth. Granulations on the inner branchial and cardiac regions of the carapace.

Sex determined externally by the shape of the abdomen. Abdomen of the male T-shaped. Male gonopods (copulatory organs) reach nearly to or extend beyond the tip of the abdomen. Immature females with triangular abdomen; abdomen of mature females semi-circular. Maturity in males cannot be determined externally.

Color variable, with shades of grayish, bluish, or brownish green occurring. The propodi of chelae of

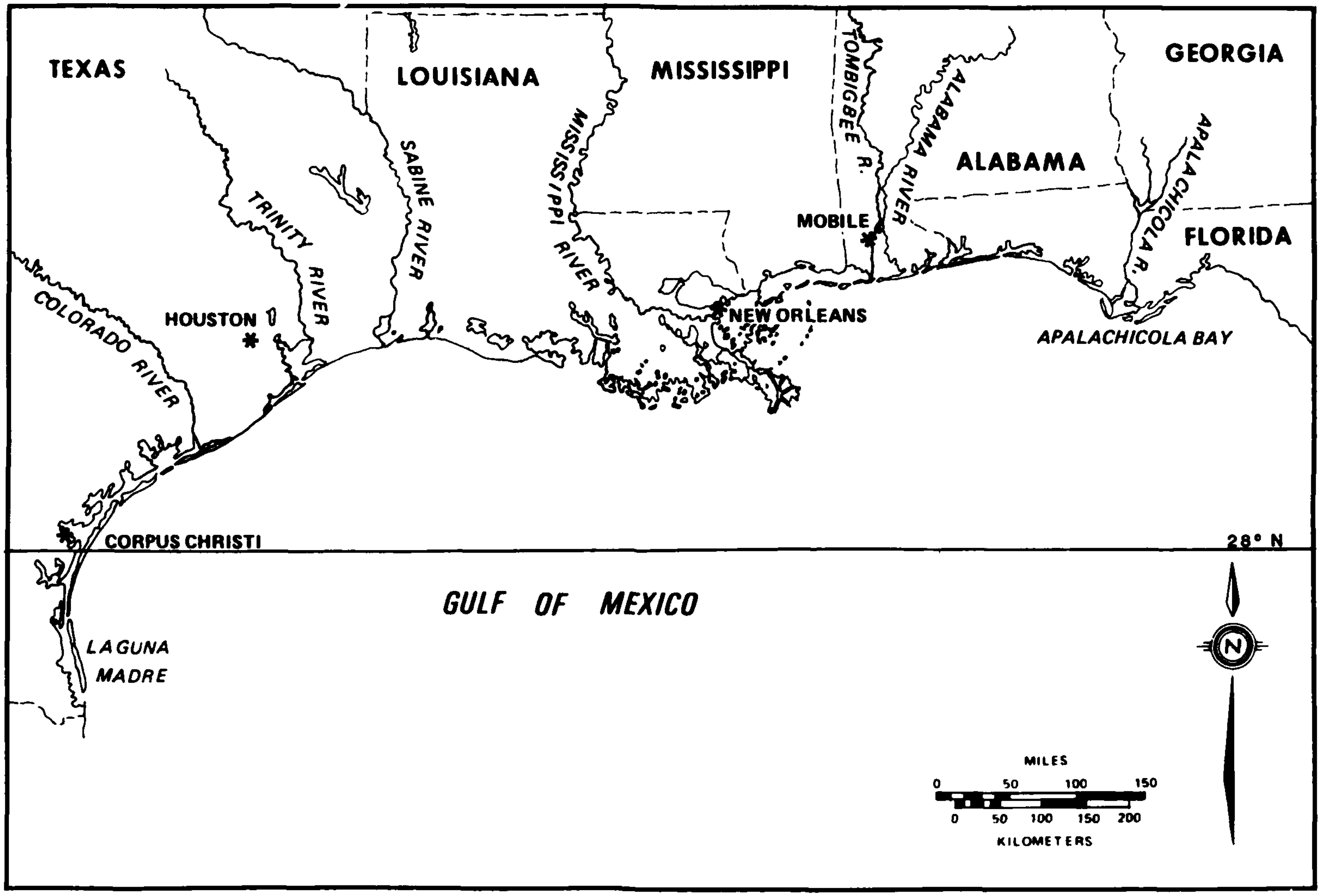

Figure 2. Blue crabs are distributed throughout the coastal waters of the Gulf of Mexico and are most abundant in waters up to 35 m. Greatest reported commercial landings occur north of 28°N latitude.

males blue on the inner and outer surfaces tipped with red. The fingers of chelae of mature females orange tipped with purple.

REASON FOR INCLUSION IN SERIES

The blue crab fisheries have become increasingly important in the Gulf States. Reported landings for the Gulf of Mexico in 1984 exceeded 51 million lb with an ex-vessel value approaching $15 million: increases of 41% and 29%, respectively, compared to 1983.[1] In addition to the commercial hard crab fishery, there exist a substantial recreational fishery and an expanding commercial and recreational fishery for soft-shelled crabs.

Blue crabs occupy a variety of habitats. The upper, middle, and lower estuary and adjacent marine area together constitute the blue crab habitat. Early larval stages are found in the lower estuary and adjacent marine waters; salinities in excess of 20.0 ppt are required for successful development. Later stage zoeae exist mainly in the open gulf where their areal and vertical distribution determine their eventual transport shoreward. Blue crabs enter the estuary as megalopae, adopting a more benthic existence. The molt to the first crab stage takes place within the estuary. Factors affecting distribution and survival include substratum, food availability, available shelter, water temperature, and salinity. Because blue crabs occupy a variety of habitats and are an integral part of the coastal ecosystem, maintenance of the entire estuarine system in a condition suitable for continued production is of prime importance.

[1]Unless otherwise noted, all statistical data presented in either the text or tables are from Fishery Statistics of the United States and Current Fishery Statistics (various years), both published by the National Marine Fisheries Service.

LIFE HISTORY[2]

Spawning

Spawning of blue crabs in northern gulf waters is protracted with egg-bearing females occurring in coastal and estuarine waters in the spring, summer, and fall (Gunter 1950, Daugherty 1952, More 1969, Adkins 1972, Perry 1975). Additionally, Adkins (1972) found evidence of winter spawning in offshore Louisiana waters based on commercial catches of "berry" crabs in December, January, and February, and Daugherty (1952) noted that crabs in southern Texas may spawn year round in years with mild winters.

For most marine animals mating and spawning are synonymous; however, in the case of the blue crab, the two events occur at different times. The female mates in the soft-shell state following the pubertal or terminal molt (in the female blue crab the cycle of growth and molting terminates with a final ecdysis). After insemination, the male continues to carry the female until her shell has hardened. Spawning usually occurs within 2 months of mating in the spring and summer. Females that mate in the fall usually delay spawning until the following spring. Sperm transferred to the female remain viable for a year or more and are used for repeated spawnings.

The fertilized eggs are extruded and attached to fine setae on the endopodites of the pleopods, forming an egg mass known as a "sponge," "berry," or "pom-pom." As many as two million eggs may be present in a single sponge. The sponge is initially bright orange, becoming progressively darker as the larvae develop and absorb the yolk. Just prior to hatching, the sponge is black. The eggs hatch in about 2 weeks. Churchill (1921) and Van Engel (1958) have provided detailed data on reproduction and spawning of blue crabs.

[2]Information in the following sections was taken from Perry et al. (1984).

Larvae

Costlow and Bookhout (1959) reported seven zoeal stages and one megalopal stage (Figure 3). An eighth zoeal stage was sometimes observed though survival to the megalopal stage was rare. Development through the seven zoeal stages required from 31 to 49 days; the megalopal stage persisted from 6 to 20 days. In salinities below 20.1 ppt the larvae rarely survived the first molt.

The larval life history of the blue crab in the Gulf of Mexico is poorly understood. Although Daugherty (1952), Menzel (1964), and Adkins (1972) specifically discussed the distribution of blue crab larvae, the possibility of co-occurrence of the larvae of the lesser blue crab (C. similis) must be considered. The temporal and spatial overlap in spawning habits of the two species (Perry 1975), coupled with the difficulty in using the early morphological descriptions of the blue crab larvae from the Atlantic (Costlow and Bookhout 1959) to reliably identify gulf specimens, suggests that published accounts of the seasonality of blue crab larvae are questionable. Recognizing the difficulty in separating the two species, King (1971), Perry (1975), and Andryszak (1979) did not differentiate between the larvae of the blue crab and the lesser blue crab.

Perry and Stuck (1982a) noted that early stage Callinectes zoeae (I and II) were present in Mississippi coastal waters in the spring, summer, and fall. Adkins (1972) reported blue crab larvae were present year-round in Louisiana, but did not separate the zoeal and megalopal stages. The sampling programs of Menzel (1964) and Andryszak (1979) were of limited duration. Perry and Stuck (1982a) and Andryszak (1979) found only the early stage zoeae abundant nearshore.

Callinectes megalopae have been reported to occur throughout the year. Perry (1975) found megalopae in Mississippi Sound in all months; peak abundance was in the late summer-early fall and in February. In Texas coastal waters, Callinectes megalopae have been found in all seasons (Daugherty 1952, More 1969, King 1971). King (1971) noted three waves of megalopae in Cedar Bayou, Texas: the first from January through March, the second in May and June, and the third in October.

Attempts to separate the megalopae of C. sapidus and C. similis, using the characters developed by Bookhout and Costlow (1977), have been largely unsuccessful because of apparent morphological differences in larvae from the Gulf of Mexico and Atlantic Ocean. Stuck et al. (1981) and Stuck and Perry (1982) provided characters useful in distinguishing the megalopae and early crab stages of the two species. Subsequent analysis of archived plankton samples from Mississippi and Louisiana coastal waters has furnished information on the seasonality of C. sapidus megalopae in the northern gulf (Stuck and Perry 1981). Callinectes sapidus megalopae were rarely found in samples before May. These data suggest that the reported winter peaks of Callinectes larvae in the northern gulf are probably referable to C. similis.

Reports on the vertical distribution of Callinectes megalopae appear conflicting. Williams (1971), King (1971), Perry (1975), and Smyth (1980) reported megalopae to be most abundant in surface waters. In contrast, 96% of the Callinectes megalopae collected by Tagatz (1968a) and all of those collected by Sandifer (1973) were from bottom waters. Stuck and Perry (1981) found that portunid megalopae (C. sapidus, C. similis, and Portunus spp.) showed no affinity for surface or bottom waters. They noted that the majority of large catches of C. sapidus megalopae were taken on rising or peak tides, whereas the megalopae

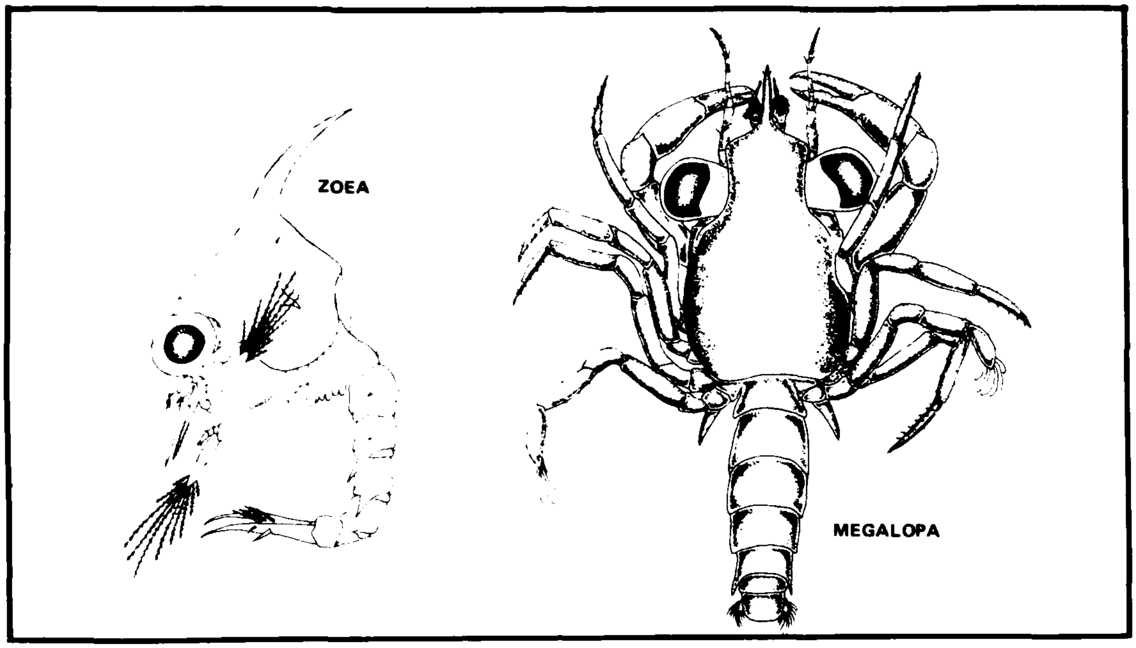

Figure 3. Larval stages of the blue crab (Stuck and Perry 1982).

of C. similis and Portunus spp. were commonly collected on both rising and falling tides.

Little is known about the mechanisms of larval transport and dispersal of blue crab zoeae in the northern gulf. Based on the data of Menzel (1964), Andryszak (1979), and Perry and Stuck (1982a), it appears that development through the late zoeal stages (III through VII) takes place in offshore waters. At this time, the larvae are subject to currents and may be transported considerable distances. Recruitment of larvae back into coastal waters occurs during the megalopal stage. Oesterling and Evink (1977) proposed a mechanism for larval dispersal in northeastern gulf waters in which blue crab larvae were transported distances of 300 km or more. If such transport mechanisms do exist in the gulf, larvae produced by spawning females in one State may in fact be responsible for recruitment in adjoining States.

Juveniles

Recruitment of blue crabs to gulf estuaries occurs during the megalopal stage (More 1969, King 1971, Perry 1975, Perry and Stuck 1982b). The relationship between numbers of megalopae recruited and subsequent abundance of juvenile crabs is not well defined. Perry and Stuck (1982b) noted that large catches of blue crab megalopae in August and September were usually followed by an increased catch of juvenile crabs (10.0 to 19.9 mm) in October or November in Mississippi estuaries; however, inconsistencies between recruitment of megalopae and subsequent occurrence and abundance of juveniles were noted in the spring and summer in their samples. King (1971) found comparable population densities of juveniles between 2 years though recruitment was markedly different. Interpretation of his data is somewhat complicated by the taxonomic problems associated with the

separation of *C. sapidus* and *C. similis* megalopae.

Juvenile blue crabs show wide seasonal and areal distribution in gulf estuaries. Livingston et al. (1976) found maximum numbers of blue crabs in Apalachicola Bay, Florida, in the winter and summer, noting that an almost "continuous succession" of juvenile crabs entered the sampling area during the year. Perry (1975) and Perry and Stuck (1982b) found first crab stages in all seasons, indicating continual recruitment to the juvenile population in Mississippi. In Lake Pontchartrain, Louisiana, Darnell (1959) noted that recruitment of juvenile crabs was highest in the late spring-early summer and in the fall.

Although juvenile crabs occur over a broad range of salinities, they are most abundant in low to intermediate salinities characteristic of middle and upper estuarine waters. Using temperature-salinity matrices, Swingle (1971), Perret et al. (1971), Christmas and Langley (1973), and Perry and Stuck (1982b) determined the distribution of blue crabs (primarily juveniles). Perret et al. (1971) and Swingle (1971) found maximum abundance in salinities below 5.0 ppt (Table 1). In contrast, Christmas and Langley (1973) and Perry and Stuck (1982b) found highest average catches associated with salinities above 14.9 ppt in Mississippi (Table 1). From 1 year of bag seine data, Hammerschmidt (1982) found no direct relationship between catches of juvenile crabs and salinity in Texas. Although salinity influences distribution, factors such as bottom type and food availability also play a role in determining distributional patterns of juvenile blue crabs.

The importance of bottom type in the distribution of juvenile blue crabs is well established. More (1969), Holland et al. (1971), Adkins (1972), Perry (1975), Livingston et al. (1976), and Perry and Stuck (1982b) all noted the association of juvenile blue crabs with soft, mud sediments. Evink (1976) collected the greatest number of individuals and biomass from mud bottoms and noted that blue crab biomass appeared to be determined by faunal food availability.

Adults

The ovarian stages described by Hard (1942) were used by Perry (1975) to define the reproductive state of blue crab populations in Mississippi. Recently mated females (Stage I) and crabs with developing ovaries (Stage

Table 1. Distribution of the blue crab by salinity intervals of 5 ppt showing number of samples (below) and catch per sample (above).

	Salinity (ppt)							
	0.0-4.9	5.0-9.9	10.0-14.9	15.0-19.9	20.0-24.9	25.0-29.9	30+	Total
Modified from:								
Swingle 1971	6.0 (41)	4.7 (15)	2.6 (14)	2.3 (19)	3.1 (33)	3.3 (18)	4.4 (18)	3.9 (179)
Perret et al. 1971	12 (197)	6 (185)	6 (263)	6 (278)	6 (182)	5 (82)	5 (12)	7 (1,199)
Christmas and Langley 1973	1.2 (134)	2.7 (87)	3.8 (110)	3.2 (99)	4.1 (145)	2.2 (169)	0.9 (74)	2.6 (818)
Perry and Stuck 1982b	7.6 (561)	7.8 (423)	7.1 ([illegible]82)	8.3 (520)	5.9 (517)	3.0 (489)	2.7 (257)	6.3 (3,249)

II) were observed in the spring, summer, and fall. Females with mature ovaries (Stage III) occurred throughout the year. The appearance of berried females (Stage IV) in March and April indicated that overwintering Stage III females spawned when water temperatures began to rise in the spring. Stage IV crabs were most abundant during the middle and late summer, corresponding with the influx of "gulf" crabs from offshore waters. Stage V crabs (repeat spawners) appeared during the summer, providing evidence that some females do spawn twice.

There is a differential distribution of male and female crabs in relation to salinity (Churchill 1921, Gunter 1950, Darnell 1959, Perry 1975). Adult males tend to remain in low salinity waters while mature females prefer the higher salinities of the lower estuary and adjacent marine waters.

Churchill (1921) noted that the maximum age for blue crabs in Chesapeake Bay was about 3 years. Tagatz (1968a) reported that the maximum age of blue crabs in the St. Johns River, Florida, was 4 years but noted that few crabs survive past 2 years of age.

Migrations

Movements of blue crabs within estuarine systems are related to life cycle stages, season, and environmental conditions (Van Den Avyle and Fowler 1984).

Migrations of females are usually associated with mating and gonadal maturation and spawning.

The migration patterns of blue crabs in the gulf observed by More (1969) and Perry (1975) were typical of the onshore/offshore movements characterized in previous studies (Fiedler 1930, Van Engel 1958, Fischler and Walburg 1962, Tagatz 1968a, Judy and Dudley 1970). Oesterling and Evink (1977) and Steele (1984) provided evidence of an alongshore movement of females in Florida coastal waters. Migratory patterns observed in their studies demonstrated movement of females to sites north of their mating estuary. Oesterling and Evink (1977) noted that the Apalachicola Bay region appeared to be a primary spawning ground for crabs along the Florida peninsular gulf coast. Steele (1984) reported that the concentration of migratory females in the Apalachicola Bay area was the result of a salinity barrier created by outflow from the Apalachicola River. A hypothesis for redistribution of larvae to southwestern Florida involved transport of zoeae in surface currents associated with Apalachicola River flow and the Gulf of Mexico Loop Current.

GROWTH

Newcombe et al. (1949) estimated the number of postlarval instars for male and female blue crabs to be 20 and 18, respectively. If the number of molts is assumed to be fixed in blue crabs (Newcombe et al. 1949, Van Engel 1958), the variability in the average size at which maturity is attained in the female, coupled with the observations that unusually large blue crabs are found in low salinities, suggests that environmental conditions influence the percentage increase in size per molt. Blue crabs in Chincoteague, Chesapeake, and Delaware Bays increase in size with decreasing environmental salinity (Porter 1955, Cargo 1958). The data of Newcombe (1945), Van Engel (1958), and Tagatz (1965, 1968a) also suggest a possible negative correlation of size with the salinity of the water in which growth occurs. Van Engel (1958) believed that the osmoregulatory mechanism was involved; differences in the levels of salt concentration between the crabs and their environment affected the uptake of water, resulting in increased

growth per molt. Haefner and Shuster (1964), in a study of the growth increments occurring during the terminal molt of the female blue crab under different salinities, concluded that "within the parameters of the experiment, the salinity variation of the environment is not related to percentage increase in length at the terminal molt." Tagatz (1968b) also reported that a decrease in salinity did not produce an increase in size and suggested that some factor other than salinity appeared to account for larger crabs in certain waters.

Growth of blue crabs is strongly affected by temperature. One of the more obvious effects of temperature on growth rate is the length of time required for crabs to reach maturity. Up to 18 months is necessary for maturation in Chesapeake Bay (Van Engel 1958), while blue crabs in the Gulf of Mexico may reach maturity within a year (Perry 1975, Tatum 1980).

In the laboratory, Leffler (1972) demonstrated that the molting rate (molts per unit of time) increased rapidly with increasing temperature from 13.0 to 27.0 °C. This increase continued at a slower rate between 27.0 and 34.0 °C and growth virtually ceased at temperatures below 13.0 °C. The growth per molt was significantly reduced above 20.0 °C. Thus, while the molting rate increased with temperature, the number of molts necessary to attain a certain size also increased. If the maximum size a blue crab attains is assumed to reflect the growth per molt rather than the number of molts, environmental temperatures may, in part, be responsible for the variation in size at maturity.

Perry (1975) estimated growth by tracing modal progressions in monthly width-frequency distributions for crabs in Mississippi Sound. The estimated growth rate of 24 to 25 mm/month is somewhat higher than rates found in other gulf estuaries. Adkins (1972) found growth in Louisiana waters to be approximately 14 mm/month for young crabs, with slightly higher rates (15 to 20 mm/month) as crabs exceeded 85.0 mm in carapace width. Darnell's (1959) growth estimate of 16.7 mm/month for crabs in Lake Pontchartrain falls within the average reported by Adkins. More (1969) noted a growth rate of 15.3 to 18.5 mm/month in Texas. Plotting the progression of modal groups from February through August, Hammerschmidt (1982) reported higher growth rates for crabs in Texas (21.4 and 25.2 mm/month for seine and trawl samples, respectively) and attributed these rates to the use of seasonal rather than yearly data. Tatum (1980) found seasonal changes in the rate of growth of young blue crabs in Mobile Bay, Alabama. He observed monthly rates of 19.0, 10.0, and 5.0 mm for crabs recruited in April, August, and December, respectively.

ECOLOGICAL ROLE

Blue crabs feed on various crustaceans, molluscs, fish, detritus, and on other blue crabs. They are usually characterized as opportunistic benthic omnivores.

Young and adult blue crabs occur in estuarine waters throughout the year and are important prey species for a variety of organisms. Many species of birds, including herons and diving ducks, feed on blue crabs. Mammalian predators include humans and the raccoon. Fish species feeding on blue crabs include spotted seatrout, red drum, black drum, croaker, gars, sheepshead, and freshwater and saltwater catfish.

THE FISHERY

Commercial Harvest

Annual commercial landings of blue crabs from the Gulf of Mexico have been reported since 1880 (Table 2).

Variations in the abundance of crabs due to environmental factors and disease, use of more efficient gear, increased fishing effort, and the economic condition of the market are reflected in historical catches of blue crabs. The fishery in Mississippi and Alabama has been relatively stable; each state reported from 1.1 million to 2.7 million lb annually. Louisiana continues to be the largest producer in the gulf, supplying raw product to Texas, Mississippi, and Alabama processing plants. Landings for Louisiana have fluctuated widely although reported landings from 1975 to 1980 have not approached the 1973 landings of 23 million lb. Florida gulf coast landings have remained relatively stable at 13 million lb after declining from 21 million lb in 1965 to 9 million lb in 1968. Landings in Texas approached 9 million lb in 1980. The percentage contributions of each State to the total Gulf of Mexico blue crab landings from 1960-1980 are shown in Table 3; the gulf coast of Florida and Louisiana have contributed the highest percentage since 1960. The percentage contributions of gulf landings to total U.S. landings (1960-80) are shown in Table 4.

Seasonal fluctuations in reported commercial landings are similar among all the Gulf States (Figure 4). Com-

Table 2. Historical commercial landing statistics by State for hard shell blue crab, 1880-1980, in thousands of pounds and thousands of dollars (from Perry et al. 1984).

	Florida West Coast		Alabama		Mississippi		Louisiana		Texas		Total	
Year	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1880							288	7	36	1	324	8
1887	(2)	(2)	(2)	(2)	38	1	837	13	111	4	(2)	(2)
1888	3	(1)	96	6	16	(1)	851	13	115	4	1,081	23
1889					48	1	842	14	189	5	1,079	20
1890	-	-			33	1	851	13	191	5	1,075	19
1891	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1892	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1895	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1897	6	(1)	24	1	132	3	1,459	13	138	4	759	21
1898	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1899	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1901	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1902	1	(1)	75	2	235	5	312	16	43	2	1,666	25
1904	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1905	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1908	2	(1)	246	6	380	10	244	8	199	5	1,071	29
1915	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1918			96	3	216	6	282	10	193	11	787	30
1919	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1920	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1921	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1922	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1923			84	3	435	11	312	8	109	9	940	31
1924	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1925	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1926	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1927	12	1	32	1	2,426	62	1,091	51	121	9	3,682	124

Table 2. (Continued).

Year	Florida West Coast Quantity	Florida West Coast Value	Alabama Quantity	Alabama Value	Mississippi Quantity	Mississippi Value	Louisiana Quantity	Louisiana Value	Texas Quantity	Texas Value	Total Quantity	Total Value
1928	7	1	102	4	1,518	40	2,320	78	300	12	4,247	135
1929	2	(1)	103	3	1,247	33	2,675	78	163	11	4,190	125
1930	4	(1)	80	1	673	11	4,186	63	29	1	4,972	76
1931	4	(1)	78	1	454	7	4,985	53	49	1	5,570	62
1932	4	(1)	70	1	320	5	5,878	57	45	1	6,317	64
1933	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1934	49	1	257	4	603	7	11,676	164	258	13	12,843	189
1935	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1936	821	12	997	14	2,011	30	12,576	168	320	8	16,725	232
1937	775	12	756	11	1,435	25	14,717	195	922	24	18,605	267
1938	1,104	16	511	8	1,016	17	10,533	106	971	24	14,135	171
1939	722	11	558	8	1,469	25	11,228	129	406	8	14,383	181
1940	1,170	16	1,381	28	1,488	26	14,062	172	252	6	18,353	248
1941	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1942	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1943	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1944	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1945	1,092	54	2,207	110	5,639	282	31,280	1,418	339	39	40,557	1,903
1946	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1947	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1948	(2)	(2)	2,373	119	5,503	275	21,110	608	526	34	(2)	(2)
1949	2,056	91	2,128	106	4,163	208	17,874	555	374	22	26,595	982
1950	684	27	599	26	4,040	202	13,106	599	387	30	18,816	884
1951	2,076	83	1,109	46	1,623	82	8,710	461	280	24	13,798	696
1952	1,984	89	655	39	1,726	86	7,334	314	338	24	12,037	552
1953	3,153	126	1,087	54	1,412	71	8,131	333	432	39	14,215	623
1954	2,903	145	972	49	1,256	68	7,085	294	379	26	12,595	582
1955	4,954	248	1,613	81	1,763	88	10,811	449	356	29	19,497	895
1956	3,728	180	725	36	1,979	99	9,402	433	195	20	16,029	768
1957	5,302	318	1,462	73	2,400	144	8,559	419	201	11	17,924	965
1958	8,693	461	1,182	56	2,124	123	9,336	402	570	51	21,905	1,083
1959	13,895	681	1,093	57	3,003	165	9,570	461	1,192	75	28,753	1,439
1960	18,648	895	499	26	2,812	169	10,050	497	2,867	177	34,876	1,764
1961	17,130	736	838	46	2,505	143	11,910	514	2,875	178	35,258	1,617
1962	10,356	487	634	35	907	55	9,523	463	4,473	289	25,893	1,329
1963	13,148	644	1,297	75	1,112	64	7,982	447	2,980	199	26,519	1,429
1964	14,068	843	1,762	110	1,286	82	5,692	379	2,484	175	25,292	1,589
1965	20,598	1,185	1,812	153	1,692	131	9,284	635	3,622	286	37,008	2,390
1966	16,547	912	2,183	182	1,457	105	7,986	537	2,778	228	30,951	1,964
1967	13,976	817	2,353	188	1,015	79	7,559	520	2,625	222	27,528	1,826
1968	9,008	674	1,980	159	1,136	108	9,551	807	4,084	329	25,759	2,077
1969	11,584	1,074	1,920	223	1,740	177	11,602	1,072	6,343	599	33,189	3,145
1970	14,786	1,076	1,407	144	2,027	193	10,254	928	5,525	509	33,999	2,850
1971	12,279	952	1,997	212	1,259	126	12,186	1,256	5,810	567	33,531	3,113
1972	10,673	959	1,613	195	1,362	169	15,083	1,777	6,464	653	35,195	3,753
1973	9,599	1,147	2,098	294	1,815	231	23,080	2,811	6,881	830	43,473	5,313
1974	10,134	1,280	1,826	284	1,667	227	20,640	2,701	6,088	832	40,355	5,324
1975	12,807	1,585	1,640	283	1,137	177	17,144	2,510	5,992	948	38,720	5,503
1976	12,048	1,966	1,299	281	1,335	268	15,211	3,061	6,668	1,179	36,561	6,755
1977	15,832	3,119	2,174	548	1,919	473	16,379	3,765	8,249	1,947	44,553	9,852
1978	11,679	2,235	2,009	458	1,940	423	15,207	3,189	7,470	2,004	38,305	8,309
1979	11,198	2,235	1,314	383	1,311	316	17,370	3,885	8,312	2,146	39,505	8,965
1980	11,263	2,392	1,557	464	2,748	690	16,342	3,874	8,953	2,456	40,863	9,876

(1) less than 500 pounds or $500.00.
(2) - data not available.

Table 3. Percent contribution by State to total gulf landings of blue crab 1960-80.

Year	Florida-west coast	Alabama	Mississippi	Louisiana	Texas
1960	53.5	1.4	8.1	28.8	8.2
1961	48.6	2.4	7.1	33.8	8.2
1962	40.0	2.4	3.5	36.8	17.3
1963	49.6	4.9	4.2	30.1	11.2
1964	55.6	7.0	5.1	22.5	9.8
1965	55.7	4.9	4.6	25.1	9.8
1966	53.5	7.1	4.7	25.8	9.0
1967	50.8	8.5	3.7	27.5	9.5
1968	35.0	7.7	4.4	37.1	15.9
1969	34.9	5.8	5.2	35.0	19.1
1970	43.5	4.1	6.0	30.2	16.3
1971	36.6	6.0	3.8	36.3	17.3
1972	30.3	4.6	3.9	42.9	18.4
1973	22.1	4.8	4.2	53.1	15.8
1974	25.1	4.5	4.1	51.1	15.1
1975	33.1	4.2	2.9	44.3	15.5
1976	33.0	3.6	3.7	41.6	18.2
1977	35.5	4.9	4.3	36.8	18.5
1978	30.5	5.2	5.1	39.7	19.5
1979	28.3	3.3	3.3	44.0	21.0
1980	27.6	3.8	6.7	40.0	21.9

mercial crabbing generally begins in March or April as water temperatures rise above 15 °C. Greatest commercial catches usually occur from May through August with June or July as peak months. Reported landings then begin to decline along with water temperature. These general trends may shift slightly from month to month, depending upon prevailing environmental and/or market conditions.

Dominant commercial gear types used to harvest hard blue crabs in the gulf are trawls, trotlines and crab pots. Use of pots has increased greatly since 1948, while use of trotlines has declined.

Recreational Harvest

Accurate data on the recreational catch of crabs in the gulf are lacking. The sport fishery is thought to contribute significantly to total fishing pressure, though estimates of the impact of recreational fishing on the resource vary widely.

Tatum (1982) conservatively estimated that the recreational catch in Alabama equaled approximately 20% of the annual commercial catch. From interviews with 810 sports fishermen in the Mississippi coastal zone, Herring and Christmas (1974) estimated a recreational catch of 50,000 lb of hard crabs in 1971. Compared to commercial landings of 1,259,230 lb for that year, the sports catch represented less than 4% of the total. Data from a recreational survey of Galveston Bay, Texas, produced similar results. Benefield (1968) estimated

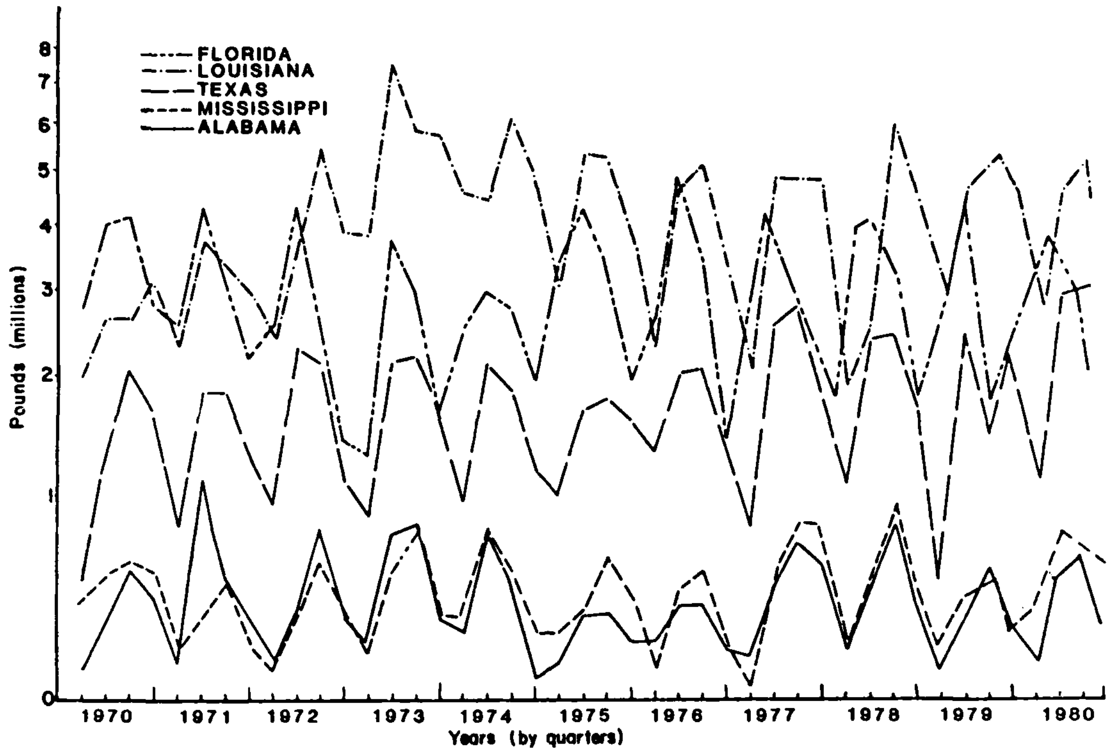

Figure 4. Seasonal blue crab landings by State, 1970-80 (Perry et al. 1984).

the recreational catch of blue crabs from Galveston Bay to be 33,125 lb or 5.9% of the commercial harvest from that area.

In Louisiana the sport fishery landings were estimated to exceed the commercial fishery landings by almost four times. On the basis of a sport crab survey conducted by the Bureau of Sports Fisheries and Wildlife in 1968, the estimated recreational catch of blue crabs in Louisiana was 29 million lb (Lindall and Hall 1970), compared to commercial hard and soft crab reported landings of 9.5 million lb and 284,000 lb, respectively. Total commercial gulf landings of hard crabs for the survey period were 25.7 million lb; thus, the estimated recreational catch in Louisiana alone exceeded the reported commercial hard crab landings from all Gulf States in 1968. These data emphasize the need for accurate recreational catch statistics in order to estimate total production.

Incidental Harvest

In addition to the commercial and recreational hard and soft crab fisheries, large numbers of crabs are harvested as "by-catch" in other fisheries. Adkins (1972) noted that commercial shrimp fishermen in Louisiana "eat, give away, swap for supplies or sell many of the crabs they catch while trawling for shrimp." Adkins (1972) also reported that during the late fall and winter, crabs are frequently taken in shrimp trawls following strong cold fronts. He noted that one shrimper, trawling in the mouth of a deep bayou, caught 8,000 to 9,000 lb of crabs in a single day. These crabs were sold but

Table 4. Percent contribution of gulf landings of blue crab to total U.S. blue crab landings.

Year	Percent
1960	23.3
1961	23.9
1962	17.3
1963	18.7
1964	16.6
1965	22.2
1966	18.6
1967	19.0
1968	22.7
1969	25.1
1970	23.4
1971	22.5
1972	23.9
1973	31.8
1974	27.1
1975	30.0
1976	32.3
1977	34.6
1978	27.7
1979	25.8
1980	25.0

no record of the transaction was made. Commercial and recreational butterfly or wing net (paupier) fishermen also harvest large numbers of crabs. According to Adkins (1972) these "paupier" crabs are "eaten, given to friends, or sold, thus not entering into commercial landings." Data on incidental catch from other Gulf States are lacking.

Factors Affecting Commercial Landings

According to Van Engel (1982), fluctuations in Chesapeake Bay landings result primarily from variations in year-class strength and distribution of the stock, both of which he considered largely influenced by density-independent environmental variables. Using simple and multiple correlation analyses to determine the relationship between environmental variables and subsequent harvest, Van Engel and Harris (1979) found that three parameters accounted for 86% of the variation in commercial landings from September 1965 through August 1975. These variables were identified as the cooling degree days at Norfolk, Virginia, in May of the year of the hatch; meridional wind stress off Delaware Bay in January following the year of the hatch; and an index of juvenile crab abundance from the York River in fall of the year of the hatch and in the following spring and summer.

More (1969) listed changes in recruitment to the fished population and migrations to and from fishing grounds as factors influencing landings in Galveston Bay, Texas. In Florida, Tagatz (1965) reported that market conditions as well as crab migrations and year-class strength were influential in determining the level of commercial catch. While variations in year-class strength undoubtedly influence commercial harvest, the use of landings data as an index of adult stock abundance may be misleading.

The relationship between commercial landings (blue crabs, oysters, penaeid shrimp) and long-term environmental factors was investigated by Meeter et al. (1979) for the Apalachicola Bay estuarine system in Florida. They found that while there were initial indications that long-term flow from the Apalachicola River influenced annual commercial landings of blue crabs from Franklin County, when catch data from other species were partialled out, river flow explained very little of the annual variation in blue crab harvest. The authors suggested that unidentified socioeconomic variables and individual species strategies relative to short- and long-term climatic changes may in part be responsible for the lower "r" values observed with partial correlation analysis. According to Lyles (1976), fluctuations in the commercial catch of blue crabs appear to be

governed more by economic conditions than by a scarcity of crabs. Moss (1981) noted that landings do not necessarily reflect populations, but may only reflect economic fluctuations.

ENVIRONMENTAL REQUIREMENTS

Both density-independent and density-dependent variables operate to influence larval and juvenile population levels. The vulnerability of blue crabs to changing environmental conditions is perhaps greatest during the larval and juvenile stages. While current and past crab research has emphasized the role of the nursery area as a limiting factor in determining the success of a year-class or modal group, conditions that affect the initial movement of larvae and postlarvae toward the estuary must also be considered. The differential distribution of early and late stage zoeae, though it helps assure mixing of populations, subjects recruitment to the vagaries of offshore transport. The role that offshore recruitment plays in determining levels of young on estuarine nursery grounds is currently under investigation.

Laboratory studies on *Callinectes* larvae indicate that there is a behavioral basis for the vertical distribution of blue crab zoeae. According to Sulkin (1981), "experiments indicate that during the course of blue crab zoeal development changes occur in critical behavioral responses which, through ontogeny, produce a characteristic pattern of differential vertical distribution." From these observations he developed a dispersal-based recruitment model for the Middle Atlantic Bight which included mechanisms for both the estuarine retention of larvae and the recruitment of larvae from offshore. He noted that significant retention of larvae is most likely to occur in stratified estuaries which are wide with respect to depth near the mouth. In such an estuary, larvae released at a depth below the pycnocline would be retained. Most field data indicate, however, that *C. sapidus* larvae are released to surface waters and, consequently, transported offshore. As these zoeae progress in their development, they move to deeper waters which have pronounced landward drift. This drift concentrates late-stage zoeae and megalopae near the mouths of estuaries. The literature indicates that recruitment to the estuary occurs in the megalopal stage (Tagatz 1968a, More, 1969, King 1971, Perry 1975). The Sulkin (1981) model predicts that for large, stratified estuaries, there is a low but stable base-level of recruitment via retention that is augmented by a highly variable degree of recruitment from offshore; it is the level of this offshore recruitment that is responsible for the annual variations in recruitment success. In smaller estuaries that are stratified aperiodically, or in which stratification is less stable, blue crab recruitment would be more sensitive to the uncertainties of the offshore larval pool and recruitment would be more variable. Mechanisms of larval transport and the effects of changing environmental conditions on survival of larvae in the Gulf of Mexico are aspects of the life history of blue crabs that have received little attention from biologists.

Once the megalopae have reached the estuary, the major concerns for survival are related to maintenance of adequate habitat and favorable environmental conditions on the nursery grounds.

Variations in salinity, temperature, pollutants, predation, disease, habitat loss, and food availability all affect survival. The diversity of these parameters and their possible synergistic effects make precise identification of the influence of specific variables difficult. Additionally, the effects of variables

such as salinity may be intrinsic (physiological) or extrinsic (affecting the composition of the biotic environment). Van Engel (1982) suggested that temperature, salinity, and substratum are the primary factors affecting growth, survival, and distribution of blue crabs in Chesapeake Bay. Salinity has been identified as a determinant affecting blue crab abundance in Texas bays (Hoese 1960, More 1969). More (1969) found an inverse relationship between salinity and the abundance of juvenile crabs and noted that low crab stocks on the lower Texas coast from 1963 to 1965 were associated with drought conditions. In contrast, Livingston et al. (1976) noted that temperature and salinity might not be as critical in the determination of estuarine population levels as are biological parameters. They observed that biological parameters related to trophic phenomena may play an important role in estuarine population shifts.

Blue crab mortalities associated with chemical and biological pollutants, sediment, temperature, salinity, and dissolved oxygen were discussed by Van Engel (1982). One of the most serious incidences of chemical pollution affecting the blue crab fishery occurred in Virginia and was associated with the release of the chlorinated hydrocarbon Kepone into the James River from the late 1950's to late 1975. Closure of the river to commercial fishing had a severe negative effect on the industry throughout the Chesapeake Bay. The annual mortality of young and adult blue crabs due to exposure to Kepone remains unknown; however, both commercial landings and juvenile crab abundance have been lower in the James than in the York or Rappahannock Rivers for the past 15 years (Van Engel 1982). Lowe et al. (1971) reported Mirex (closely related to Kepone) to be toxic to blue crabs either as a contact or stomach poison.

Low levels of dissolved oxygen not only cause mortality of blue crabs but also impede migration. Death in crab traps due to anoxia is a serious problem in many areas. Tatum (1982) reported that oxygen-deficient bottom waters covered as much as 44% of Mobile Bay, Alabama, in the summer of 1971, with some area fishermen reporting that as much as 75% of their catch was dead. Low levels of dissolved oxygen in the deeper waters of Chesapeake Bay and associated tributaries during the summer months have also been implicated in trap death. Periodic kills of blue crabs following excessive freshwater runoff and the subsequent depletion of oxygen due to rapid decomposition of organic matter were reported by Van Engel (1982).

Other mortalities of blue crabs have been related to extreme cold or to sudden drops in temperature (Gunter and Hildebrand 1951, Van Engel 1978 cited by Rhodes and Bishop 1979, Van Engel 1982, Couch and Martin 1982) and to red tides (Wardle et al. 1975, Gunter and Lyles 1979).

Mass mortalities of blue crabs occurred in South Carolina, North Carolina, and Georgia in June 1966 and in South Carolina and Georgia in June 1967. While the pathogenic amoeba (*Paramoeba perniciosa*) was alluded to as a possible cause of the mortalities, there was some implication that pesticides may have been involved. According to Newman and Ward (1973), blue crab mortalities of greater and lesser magnitude have occurred during May and June with *Paramoeba* involved in the majority of the kills that were investigated.

Large numbers of dead crabs have periodically littered the beaches of Louisiana (Adkins 1972) and Mississippi (Perry 1975). The vast majority of these crabs were heavily fouled, spent females.

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50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. Biological Report 82(11.55)	2.	3. Recipient's Accession No.

4. Title and Subtitle
SPECIES PROFILES: LIFE HISTORIES AND ENVIRONMENTAL REQUIREMENTS OF COASTAL FISHES AND INVERTEBRATES (GULF OF MEXICO) -- BLUE CRAB

5. Report Date June 1986

6.

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8. Performing Organization Rept. No.

9. Performing Organization Name and Address
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10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
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13. Type of Report & Period Covered

14.

15. Supplementary Notes
U.S. Army Corps of Engineers Report No. TR EL-82-4

16. Abstract (Limit: 200 words)

Species profiles are summaries of the literature on taxonomy, morphology, range, life history, and environmental requirements of coastal aquatic species. They are designed to assist in environmental impact assessment. The blue crab, Callinectes sapidus, is common in tidal marsh estuaries and coastal waters of the Gulf of Mexico, occupying a variety of habitats depending upon the physiological requirements of each particular stage in its life history. Spawning occurs from spring through fall in high salinity estuarine and/or coastal waters. Development through the 7 zoeal stages requires approximately 31 days and occurs offshore. The megalopal stage is usually completed within a week. Recruitment to the estuary occurs during the megalopal stage. Molt to the first crab takes place within the estuary. Juveniles exhibit wide seasonal and areal distribution. Growth is rapid and blue crabs in the Gulf of Mexico may reach maturity within a year. Factors affecting growth and survival include food availability, predation, substratum, available habitat, temperature, salinity and pollutants. Blue crabs do not conform to specific trophic levels and are characterized as opportunistic benthic omnivores. Their diverse feeding habits and their importance as prey species for a variety of organisms make them an integral part of coastal ecosystems.

17. Document Analysis a. Descriptors

Estuaries, Fisheries, Salinity, Temperature, Feeding habits, Crabs, Life cycles, Growth, Oxygen, Contaminants

b. Identifiers/Open-Ended Terms

Blue crab, Callinectes sapidus, Salinity requirements, Temperature requirements, Habitat requirements

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited	Unclassified	21
	20. Security Class (This Page)	22. Price
	Unclassified	

(See ANSI-Z39.18)

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
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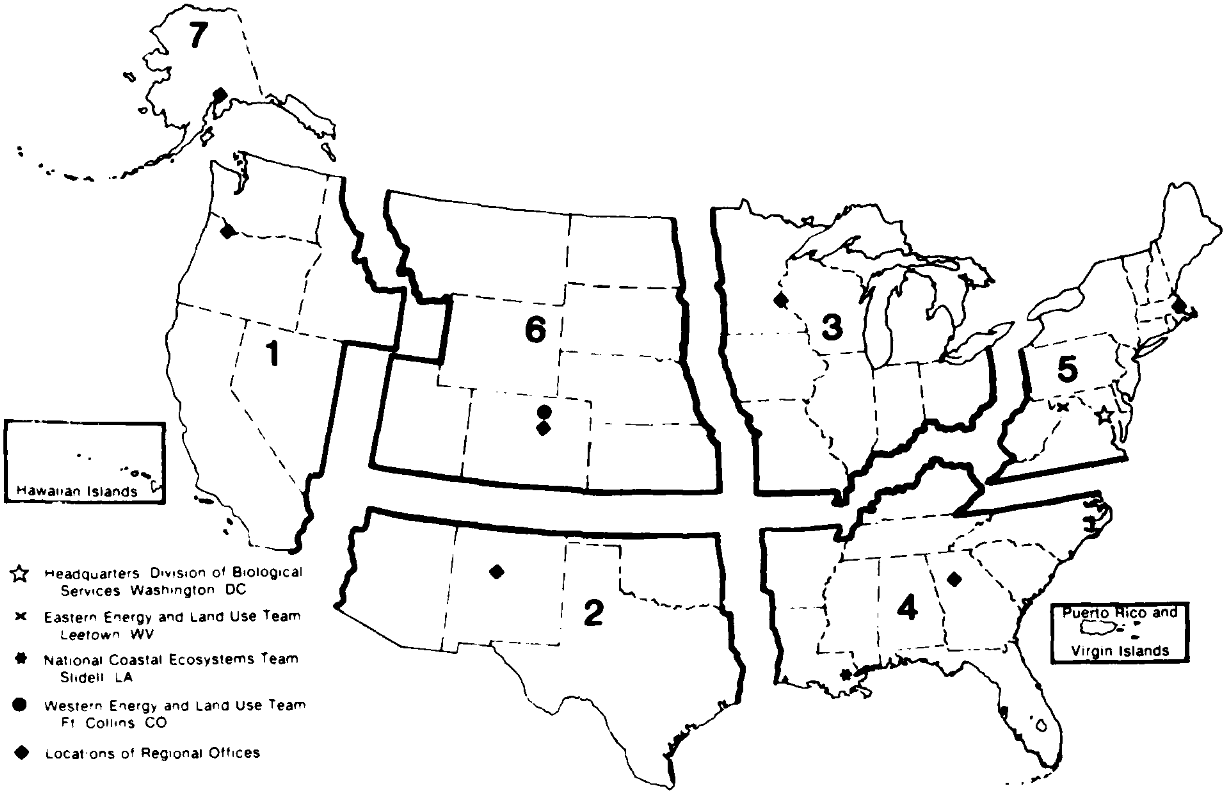

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